DOCUMENT RESUME

ED 280 718 SE 047 881

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TITLE Basic Skills and Macro- and Micro-Analysis of Mathematics Achievement of Grade Ten Students as a Function of Gender and Locale.
SPONS AGENCY Saskatchewan Dept. of Education, Regina.
PUB DATE 87
NOTE 23p.; Paper presented at the Canadian Educational Research Association Conference (Hamilton, Ontario, May 31-June 3, 1987).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Processes; Educational Research; Foreign Countries; Grade 10; *Mathematics Achievement; *Mathematics Instruction; Mathematics Skills; Secondary Education; *Secondary School Mathematics; *Sex Differences; Testing
IDENTIFIERS Canada; *Mathematics Education Research

ABSTRACT

A large and representative 10% sample of classrooms consisting of 1,587 students from a mid-western province in Canada was administered a standardized achievement test battery. This battery consisted of four tests, Reading, Mathematics, Written Expression, and Using Sources of Information. Gender and rural-urban differences in achievement and macro- and micro-skills in mathematics were examined. Females, as expected, were superior to males in all except the mathematics test, in which males were better than females. Though Manova results suggested rural-urban differences in achievement, the corresponding Anovas for the four tests confirmed the null hypothesis. An analysis of the mathematics items when grouped into three mental-process or macro-skill categories showed that males were better than females on only the problem solving component. However, males and females from rural classrooms were similar on computation but in the urban classrooms males were better than females. Students from rural classrooms achieved better on concepts than those from urban classrooms. Similarly, an analysis of eight mathematics components, comprising content-specific mental prcesses, produced sex differences on three components and locale differences on two. These findings are interpreted in relation to contemporary theory and research. (Author)

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ED280718

Basic Skills and Macro- and Micro-Analysis of Mathematics Achievement of Grade Ten Students as a Function of Gender and Locale

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Running head: ACHIEVEMENT DIFFERENCES

A paper presented at the Canadian Educational Research Association Conference, Hamilton, Ontario, May 31 - June 3, 1987.

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Abstract

A large and representative 10% sample of classrooms consisting of 1,587 students from a mid-western province in Canada was administered a standardized achievement test battery. This battery consists of four tests, Reading, Mathematics, Written Expression, and Using sources of Information. Gender and rural-urban differences in achievement and macro- and micro-skills in mathematics were examined. Females, as expected, were superior to males in all except the Mathematics test, in which males were better than females. Though Manova results suggested rural-urban differences in achievement, the corresponding Anovas for the four tests confirmed the null hypothesis.

An analysis of the mathematics items when grouped into three mental-process or macro-skill categories showed that males were better than females on only the problem solving component. However, males and females from rural classrooms were similar on computation but in the urban classrooms males were better than females. Students from rural classrooms achieved better on concepts than those from urban classrooms. Similarly, an analysis of eight math components, comprising content-specific mental processes, produced sex differences on three components and locale differences on two. These findings are interpreted in relation to contemporary theory and research.

Basic Skills and Macro- and Micro-Analysis of Mathematics Achievement of Grade Ten Students as a Function of Gender and Locale

A number of studies have reported sex differences in ability and achievement. However, these reported differences in high school populations generally are such that males achieve better than females in quantitative tests and females attain better scores than males in verbal tests (Bachman, 1972; Fox, 1976; Fox Brody & Tobin 1980; Garai & Scheinfeld, 1968; Maccoby & Jacklin, 1974; National Assessment of Educational Progress, 1975; Randhawa & Hunt, in press). Furthermore, Randhawa and Fu (1973), after an extensive review of learning environments, pointed out that it is possible that rural pupils may be disadvantaged in terms of the larger society. But, the societal structure and the facilities available in rural and urban areas since the early 1970s have changed rather remarkably. Therefore, an expectation of achievement differences between rural and urban students based on the late 60s and 70s demographic and socioeconomic classifications may not now be appropriate.

A study of grade three children in Alberta reported that children from rural schools performed better than those from urban schools in reading, mathematics, and language (Clarke, Nyberg & Worth, 1980). The Randhawa and Hunt (in press) study was based on the data collected in 1978. Nevertheless, the results of their study showed that rural grade 10 students scored better than their urban counterparts on Capitalization and Punctuation,

and English Expression subtests; however on the other subtests of the Sequential Tests of Educational Progress administered in their study the two groups had equivalent means. Also, their results showed that females scored better than males on Reading, Spelling, Capitalization and Punctuation, English Expression, and Mathematics Computation subtests, while males outperformed females only on the Mathematics Basic Concepts (MC) subtest. When the MC subskills were analyzed, gender differences were unsystematic; on one subskill males outscored females while on two of the remaining subskills females outperformed males.

Benbow and Stanley (1980, 1981, 1982) reported large and consistent sex differences in favor of males at the seventh-grade level in mathematical reasoning. Since formal instruction in and exposure to mathematics up to the seventh-grade are similar for boys and girls, Benbow and Stanley refuted the plausibility of the argument by Fennema and Sherman (1977) that differential mathematics course-taking by males and females accounts for the gender differences in mathematical reasoning at this particular grade level. Lantz and Smith (1981) reported no gender differences in actual enrolment in or intention to enrol in mathematics courses. This evidence adds further doubt to the differential course-taking explanation to gender differences. However, Benbow and Stanley (1980) provide an alternative explanation for the observed gender differences in mathematics in higher grades and specifically state that "less well-developed mathematical reasoning ability contributes to females taking

fewer mathematics courses and achieving less well than males" (p. 1262). But, how does mathematical reasoning ability develop? One could possibly trace the classical and contemporary nature-nurture debate on this issue. However, this effort would not necessarily resolve this issue. Nevertheless, an alternative explanation for gender differences is socioculturally induced cognitive knowledge-base and meta-cognitive processes. Our acquisition of knowledge-base and meta-cognitive processes and their retention and deployment depend largely on the perceived importance of these for the adaptive and purposive needs of our culture (Randhawa, 1985). Theoretically, purpose or goal may appear to be an extraordinarily simple matter for social and moral development. However, it is an exceptionally difficult target to accomplish. As purposive behavior begins to yield results, it may become self-reinforcing. Therefore, purposive action and effort could be equally appropriate and effective mechanisms for academic development. In the former context, Csikszentmihalyi and McCormack (1986) specifically stated: "What youngsters need, more than anything else, is purpose: meaningful goals toward which to channel their energies" (p. 417).

As there have been major sociocultural shifts in the last decade in our orientation and values with regard to the contributions of men and women to our society, it is important to determine whether there have been concomitant shifts in the traditional patterns of achievement of males and females and of students from rural and urban centres. The present study

addresses these issues on the basis of a representative 10% grade ten sample from a mid-western province in Canada. Specifically, it is hypothesized that there will be no gender or locale differences on academic basic skills and on components of mathematics achievement.

Method

Sample

Each school jurisdiction in a mid-western province of Canada was requested to provide a list of classrooms for grade 10. The target sampling unit was the individual student; however, in order to minimize disruption and to maximize administrative cooperation, a 10% random sample of classrooms was chosen. A total of 79 classrooms with a student enrolment of 1,587 participated in the study. Complete data were available on 1,490 students and 1,555 students wrote the mathematics test.

Procedure

All the testing in a school jurisdiction was coordinated by the Director/Superintendent of Education or his/her designate. Students were administered the complete battery of tests, Reading, Mathematics, Written Expression (W Exp), and Using Sources of Information (USI), of the Canadian Tests of Basic Skills, Form 5 (King, 1982) in their respective schools by the classroom teachers between October 1 and November 12, 1985 in the same order over a two-day period. The completed answer sheets from each class within a jurisdiction were forwarded to the researcher.

Analysis and Results

A two-factor (Sex x Locale) multivariate analysis of variance (Manova) was employed to analyze the data. The first analysis was carried out using the raw scores of the four CTBS tests. Since, a specific interest of the present study was to examine the gender differences on the Math test, the second analysis was carried out using the proportions of items correctly answered, on the three mathematics process macro-skills, computation, concepts, and problem solving. These macro-skills cut across the content areas. A third analysis was performed using mathematics content-specific process micro-skill subscores. In this analysis, in certain instances, items within a specific process category were combined across two or more content areas so that there were at least four items in the amalgamated cluster. Hence eight micro-skills were used in the third Manova.

A significant multivariate sex effect for the four CTBS tests was obtained, $F(4, 1483) = 59.1$, $p \leq .05$. In Table 1 are given the observed means on the four tests by sex and locale . The corresponding univariate significant differences in favor of girls were observed on all the tests except Mathematics in which boys did better than girls. However, the girls superiority on the USI test was not maintained in the Roy-Bargman stepdown F-test, in which the influence of the other three tests was partialled out.

Insert Table 1 here

There was a significant multivariate locale effect for the four tests, $F(4, 1483) = 2.6$, $p \leq .05$. However, none of the univariate results was significant. But, the Roy-Bargman stepdown F-tests indicated that when the influence of the other three tests was controlled, the locale effect for the USI test was significant. As can be seen in Table 1, on the USI test the rural students achieved somewhat better than the urban students.

Significant locale, $F(3, 1552) = 3.1$, $p \leq .05$; sex, $F(3, 1552) = 6.3$, $p \leq .05$; and Locale x Sex, $F(3, 1552) = 2.87$, $p \leq .05$; effects were observed when the three Mathematics skill scores were used as dependent variables in Manova. Observed means on the three components of the Mathematics test are provided in Table 2. The univariate results indicated that rural students performed better than urban students on Concepts and that boys scored better on Problem Solving than girls. The univariate Locale x Sex interaction was significant for only the Computation subskill and is illustrated in Figure 1. Males and females from rural classrooms had equivalent scores on this component; however, the urban males were significantly better than the urban females.

Insert Table 2 and Figure 1 here

The Manova results of the eight content-specific skill scores on the Mathematics test again produced significant locale, $F(8, 1547) = 2.4$, $p \leq .05$, and sex, $F(8, 1547) = 4.8$, $p \leq .05$, effects. Observed means on these eight micro-skill clusters of the Mathematics test are given in Table 3. On three of these scores, computation involving common applications, algebra, geometry, and measurement; problems pertaining to common applications; and problems involving statistics, graphs, and tables, boys achieved better than girls. The rural students performed better than the urban students on two of these micro-skills, viz., equivalent forms and order concepts and concepts relating to basic mathematical principles. Superiority of rural students on these two concept-related micro-skills refined the previously reported concepts macro-skill difference in favor of rural students in that that on only two of the three micro-skills involving concepts differences were reliable.

Insert Table 3 here

Discussion

If results of male-female differences are considered at the general levels according to the academic-area categories, one can conclude that the results are as expected from the classical and contemporary research literature. The usual conclusion that males are better than females in quantitative areas and females are better than males in languages was upheld. Consideration of

the results at global levels provides neither a proper perspective nor an opportunity to explore fully the reasons behind the differences and to contemplate the educational, occupational, and sociocultural ramifications. In the present study, a detailed analysis of the mathematics area is presented for two reasons: 1) to determine whether the results of Randhawa and Hunt (in press) are consistent with the results of the present study; and 2) to relate these results to contemporary theory and research.

Results of the present study, in terms of the four CTBS tests, confirm previous results in terms of sex differences in achievement. However, the results of the present study are not consistent with research expectations in terms of locale differences. It has been generally held that rural youth are at a disadvantage in terms of the larger society (Edington, 1971; White & Tweeten, 1974). Even though a multivariate significant locale effect was obtained in the present study, none of the univariate results were significant suggesting that the performance of students from rural and urban locations was equivalent. These results, indicating equivalence in performance of students with respect to locale, contradict those of Clarke, Worth, and Nyberg (1980) who found children of grade 3 from non-urban schools achieve better than those from urban schools in reading, mathematics, and language and of Randhawa and Hunt (in press) using grades 4, 7, and 10 students. Specifically with the grade 10 sample, Randhawa and Hunt found that rural students were

better than urban students on Capitalization and English Expression tests of the STEP series while on the Spelling, Reading, Math Computation and Math Concepts tests the two groups were equivalent.

As a particular focus of the present study was on mathematics, the macro- and micro-skills (components) were used in subsequent analyses. On an 19-item problem solving macro-skill, males were found to achieve 3% better than girls; on the other two macro-skills, computation and concepts, the two groups were equivalent. The significant interaction on computation suggested that boys achieved better than girls only in the urban schools. However, Randhawa and Hunt (in press) showed that grade 10 girls outperformed boys in mathematics computation and that boys outscored girls in mathematics concepts; the test including both concepts and problem solving. A further analysis of the three macro-skills, when broken down into eight micro-skills, produced differences in favor of males on three micro-skills, two of which involved problem solving and one computation. Male superiority in problem solving micro-skills is consistent with that reported by Randhawa and Hunt (in press); however, the computation micro-skill result here is in contradiction to their result. It may well be that only four items comprising the computation micro-skill in the present study and the three computation subskills on which sex differences were found by Randhawa and Hunt are not comparable.

Generally, it would appear that the widely held view of male superiority in mathematics and female superiority in language tests is supported by the results of the present study using a large representative sample of grade 10 students. However, male superiority in mathematics cannot be generalized to all areas of mathematics and to all contexts. Context-specific sex differences in computation is a case in point. It is well known that problem solving requires logical thinking regardless of the content of the problem. Generalized female superiority in areas of language and expression and male superiority in mathematics and specifically in mathematics problem solving should preclude the innate or endogenous interpretation because logical thinking and reasoning are essential for doing well in both mathematics and language and expression. One possibility that has not been fully explored in explaining the gender differences in achievement is the socioculturally induced purposive and adaptive needs of individuals or groups. Just to say that biogenetic differences account for the obtained achievement differences of boys and girls does not seem to be consistent with the current thinking (see Poole, de lacey, & Randhawa, 1985; Sternberg, 1982). In spite of the sociocultural shifts that have taken place in our society, gender-specific differences still remain in some components of academic achievement. Creating purposive demand and need and shifting professional and occupational orientations of males and females might reduce further gender differences in achievement.

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Author Notes

The research reported here was supported by a contract with the Department of Education, Government of Saskatchewan. The author is grateful to Mr. Ken Horsman and other individuals who were instrumental in doing this project.

Sheryl Yuzik served as research assistant and her invaluable assistance is appreciated.

Table 1

Observed Means of the CTBS (Form 5) Tests for the Grade 10 Sample

	Sex		Locale	
	F(n=705)	M(n=785)	R(n=849)	U(n=641)
1. Reading	42.19*	39.61	40.72	40.98
2. Mathematics	27.19	28.14*	27.89	27.42
3. Written Expression	38.08*	33.42	35.44	35.87
4. Using Sources of Information	49.93*	47.46	48.28	49.10

*$p < .05$

Table 2

Observed Means of the Macro-skill Clusters on the CTBS (Form 5) Mathematics Test of Grade 10 Sample

	Sex		Locale	
Macro-Skill	F(n=742)	M(n=816)	R(n=860)	U(n=698)
1. Computation (9)[a]	5.76	5.85	5.76	5.76
2. Concepts (20)	11.40	11.60	11.60*	11.20
3. Problem Solving (19)	10.07	10.64*	10.45	10.26

[a] Figures in parentheses are the number of items in the macro-skill

*$p \leq .05$

Table 3

Observed Means of the Micro-Skill Clusters on the CTBS (Form 5) Mathematics Test of Grade 10 Sample

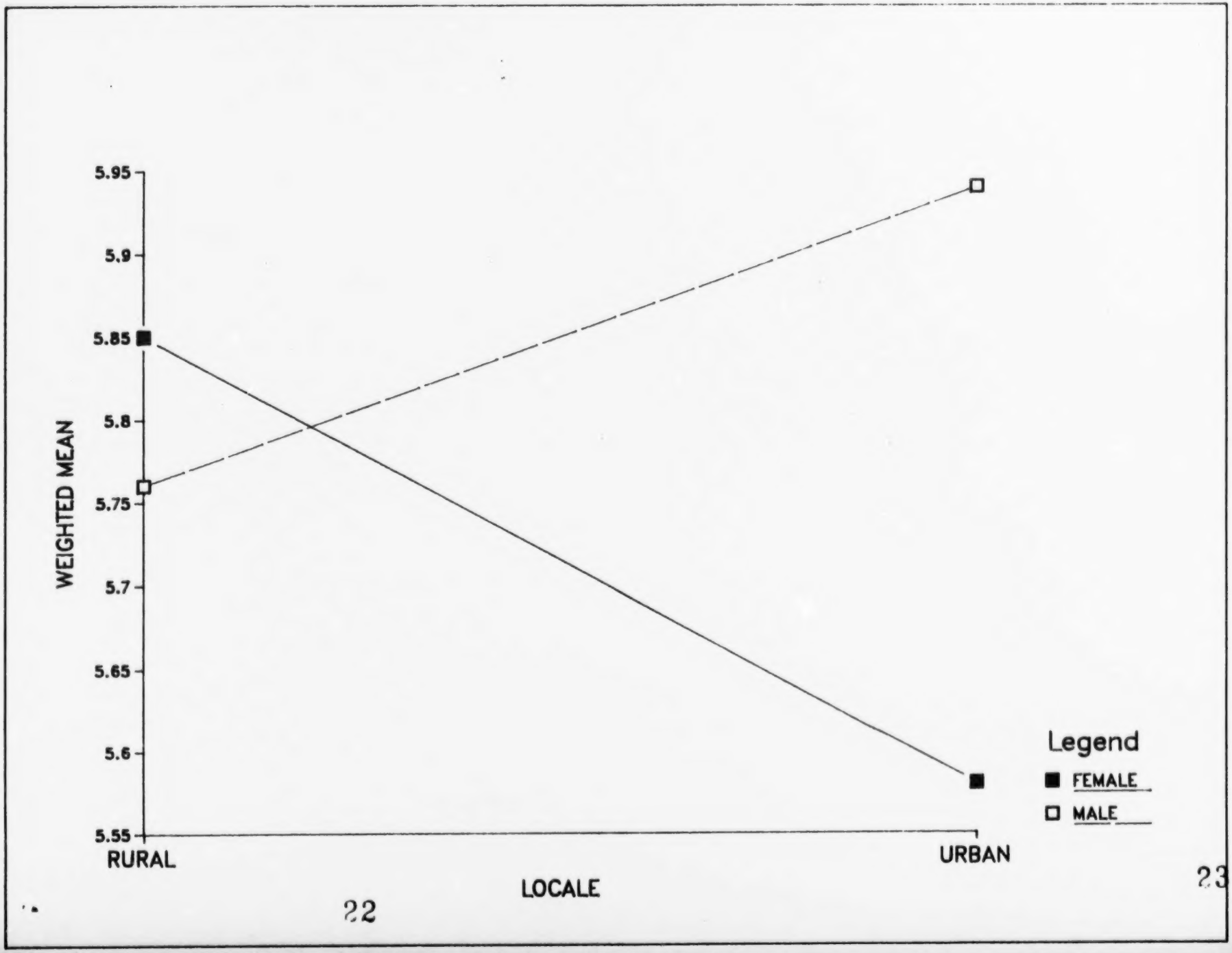
Micro-Cluster	Sex		Locale	
	F(n=742)	(M(n=816)	R(n=860)	U(n=698)
1. Operations Computation (5)[a]	3.45	3.40	3.45	3.40
2. Common Applications, Algebra, and Geometry and Measurement Computation (4)	2.24	2.44*	2.32	2.36
3. Equivalent Forms and Order Concepts (4)	2.04	2.12	2.16*	2.00
4. Common Applications, Algebra, Geometry and Measurement, and Statistics, Graphs and Tables Concepts (9)	5.40	5.58	5.49	5.40
5. Basic Mathematical Principles Concepts (7)	3.99	3.92	3.99*	3.85
6. Equivalent Forms and Order, Algebra, and Geometry, and Measurement Problems (6)	2.88	3.00	3.00	2.88
7. Common Applications Problems (9)	5.31	5.67*	5.49	5.49
8. Statistics, Graphs, and Tables Problems (4)	1.92	2.04*	1.96	2.00

[a] Figures in parentheses are number of items in the micro-skill

*$p \leq .05$

Figure Caption

Figure 1. Mean score on mathematics computation macro-skill as a function of sex and locale.


5.95
5.9
5.85
5.8
5.75
5.7
5.65
5.6
5.55
WEIGHTED MEAN
RURAL
URBAN
LOCALE
Legend
FEMALE
MALE